

CHEMICAL TREATMENT PRIOR TO PHYSICAL COAL BENEFICIATION

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ABSTRACT

Conventional wisdom dictates that chemical treatment of coal should follow physical beneficiation. This ordering is expected to achieve reduced consumption and improved access of chemical reagents to the smaller, partially demineralized coal particles which result from physical cleaning. The advantages of reversing this conventional order of treatment, particularly for coal demineralization, are often overlooked. Chemical pretreatment can greatly improve the grindability of coal prior to the final size reduction required for physical beneficiation. The use of inexpensive chemical reagents can greatly reduce the disadvantage of higher reagent consumption. Prior chemical treatment can also selectively remove inorganic components which adversely affect coal ash behavior in combustion equipment. The effectiveness of subsequent physical coal demineralization can be improved by chemical pretreatment, especially for physical processes which exploit surface chemistry. Examples describing the advantages of chemical processing prior to physical coal beneficiation are included in this talk.

INTRODUCTION

Coal beneficiation research and development programs are commonly targeted to the dual objectives of sulfur and gross mineral matter removal. Many programs are primarily guided by environmental new source performance standards (NSPS) for coal-burning facilities. Attractive technical approaches to coal beneficiation which cannot meet NSPS are given limited attention. Beneficiation objectives in addition to sulfur and gross mineral matter removal, such as improved combustion behavior, reduced slagging and fouling, improved grindability, and compatibility with emission control equipment, are often ignored.

Earlier efforts to meet NSPS and restrictive oil-backout requirements concentrated on coal hydroliquefaction. These efforts yielded conceptual processes capable of producing highly desulfurized and demineralized coal-based fuels suitable for replacing petroleum-based fuels or feedstocks. High projected process capital costs and modest overall energy yields have discouraged the further development of these conceptual processes.

Relatively high energy yields and relatively low capital and operating costs are achievable with many commercially available coal beneficiation processes. Unfortunately, these processes are capable of only modest reductions in sulfur and gross mineral matter. Newer, conceptual processes are again embarking on the path of "super-clean" coal, the same path that led to

non-competitive product costs in the case of hydroliquefaction. Other, less ambitious approaches capable of improving the performance of coal-burning equipment via coal beneficiation may be more practical. In particular, inexpensive chemical treatment prior to near-conventional physical coal beneficiation may achieve many coal beneficiation objectives.

COAL BENEFICIATION OBJECTIVES

Coal can be beneficiated to meet a variety of objectives related to its use as a heat-producing fuel. These objectives include:

- ° reducing sulfur content for reduced SO_x emissions;
- ° reducing gross mineral matter content for reduced total particulate emissions and ash production;
- ° reducing moisture levels for improved efficiency;
- ° improving grindability for reduced grinding costs;
- ° preserving combustible volatiles content for needed combustion behavior;
- ° improving carbon burnout characteristics for improved efficiency and compatibility with particulate control equipment; and
- ° reducing selected mineral components to reduce slagging and fouling characteristics of the coal ash.

Many of these objectives are in conflict. Reduced SO_x in flue gases can reduce the efficiency of electrostatic precipitators due to high particulate electrical resistivities. Gross mineral matter reduction can change the composition of resulting coal ash leading to lower coal ash fusion temperatures and increased slagging and fouling; this may in some cases be the result of contamination by beneficiation aids, such as magnetite fines carried-over during heavy media separations. Severe chemical treatments to remove sulfur and mineral matter may significantly reduce the combustible volatiles content of the coal. Very low mineral matter levels can lead to high unburned carbon levels in fly ash particulates which may reduce the efficiency of electrostatic precipitators due to low particle electrical resistivity.

Despite these conflicts, a few general objectives can be selected for top priority. Coal pyrites contribute to increased SO_x and particulate emissions and to increased slagging and fouling due to increased iron in the coal ash. Pyrite removal is an important objective for coal beneficiation. Modern coal burning applications typically require fine coal grinding (ca. <200 mesh). This is true for dry, pulverized coal firing or for coal-water mixture fuels intended for oil-backout. Improved coal grindability would significantly reduce the subsequent costs of coal utilization. The preservation of combustible volatiles in the coal is also important. It is especially important for coal/water mixture fuels due to the high moisture levels (ca. 30-40 weight percent

water) in these fuels. The preservation of combustible volatiles limits the severity, particularly temperatures, which can be employed in coal beneficiation. Pyrite removal from many coals can be improved by fine grinding. It can also be improved if fresh pyrite particle surfaces can be rendered more hydrophilic prior to froth flotation for mineral matter removal. The selective removal of alkali and alkaline earth minerals would also be desirable due to the resulting increase in coal ash fusion temperatures which would reduce slagging and fouling. In the case of dry, pulverized coal firing, the high costs of dewatering fine coal prior to burning might preclude the application of froth flotation following fine grinding.

These refined coal beneficiation objectives point towards a chemical treatment aimed at coal mineral matter, particularly the interfaces between mineral matter and the carbonaceous coal macerals. This treatment, not so very distinct from developing chemical comminution technologies should greatly improve subsequent grindability, significantly increase coal ash fusion temperatures, and preserve combustible volatiles. An additional objective of low costs requires that inexpensive reagents and treatment equipment be employed. An approach which may achieve these coal beneficiation objectives is currently under investigation at the Brookhaven National Laboratory (BNL). A pressurized carbon dioxide/water mixture is used as the chemical reagent for chemico-physical coal beneficiation⁽¹⁾.

CHEMICO-PHYSICAL COAL BENEFICIATION

Gaseous carbon dioxide is known to penetrate coal⁽²⁾ and to improve coal grindability⁽³⁾. Unlike chemical comminution caused by ammonia⁽⁴⁾, water enhances the swelling and fracturing of coal caused by carbon dioxide⁽¹⁾. The carbon dioxide/water mixture is reported to have a synergy which enhances the carbon dioxide fracturing of coal while selectively removing alkali and alkaline earth minerals. Significant improvements in coal grindability with very high retention of overall energy content and coal volatiles are reported. Subsequent sink/float studies have indicated selective fracturing of the interfaces of the mineral matter and the carbonaceous coal macerals⁽⁵⁾. Treatment effects on pyrite surface hydrophilicity for coal ground in the pressurized carbon dioxide/water mixture remain to be determined. Such improvements in the hydrophilic nature of fresh pyrite surfaces have been reported for aqueous sodium carbonate treatment at the same temperatures used in the BNL chemico-physical treatment (ca. 80°C)⁽⁶⁾.

A major drawback to this potentially effective coal beneficiation treatment is the costs of achieving the treatment conditions (ca. 750 psi, 80°C). An investigation of the effects of treatment conditions on coal beneficiation is being initiated to allow for an engineering study to evaluate the commercial potential of the BNL approach to coal beneficiation.

CONCLUSIONS

The BNL carbon dioxide/water coal beneficiation treatment shows promise for meeting important coal beneficiation objectives. This treatment appears suitable for beneficiating coals for dry, pulverized coal firing without subsequent physical coal beneficiation or for coal/water mixture fuels with subsequent physical beneficiation, e.g. froth flotation. Froth flotation is already included in the processes for some of the proposed commercial coal/water mixture preparation facilities. The effectiveness of the BNL treatment for enhancing pyrite surface hydrophilicity needs further study. Also needed is further study of the commercial potential of this coal beneficiation approach. Engineering studies await the results of more detailed investigations of the effects of varied treatment conditions.

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